Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

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| In the Matter of | ) | |
| | ) | |
| Promoting More Efficient Use of Spectrum | ) | ET Docket No. 10-237 |
| Through Dynamic Spectrum Use Technologies | ) | |

**REPLY COMMENTS OF SHARED SPECTRUM COMPANY**


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## Executive Summary

There is general unanimity among commenters in this proceeding of the value of Dynamic Spectrum Access (DSA) technologies in increasing spectrum efficiency. All see great value in the expeditious development, testing, and eventual deployment of DSA-based systems in a variety of spectrum bands.

Obviously, this will be an incremental process, as SSC has repeatedly stressed. Internal systems have already been successfully deployed in multiple operational contexts. The expedited development of systems supporting cooperative deployments represents the next logical step in the evolution of DSA technologies, to be followed, ultimately, by opportunistic deployments in other, inter alia, licensed bands.

The establishment of new, flexible test beds will be essential to the success of this undertaking. The continued evolution of a robust secondary spectrum market will be greatly enhanced by the rapid development and deployment of DSA-based systems across multiple spectrum bands, as these technologies dramatically increase the capacity of a given band. Bands suitable for early DSA deployment should be identified as soon as practicable, encouraging developments that are focused on those bands. Additionally, the creation of a comprehensive, dynamic spectrum inventory across Federal and non-Federal bands will facilitate both the development of appropriate systems and enhance their operational capabilities.

A policy-based regulatory framework of the sort described in SSC's initial comments can resolve the various interference and security related concerns expressed by certain commenters. In a well-designed DSA system, multiple tools are available for avoiding harmful interference into incumbent systems. Spectrum sensing – which is a far more dynamic and efficacious technology than was suggested by some commenters – is but one of several complementary solutions. Others include, for example, databases, geolocation, beacons, and policy-based controls. Most importantly, a well-designed DSA system will ensure the proper integration of all of these tools into a system that functions efficiently and transparently in multiple bands, geographic locations, and operational scenarios.

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## I. INTRODUCTION

Shared Spectrum Company ("SSC") respectfully submits these reply comments in response to the initial comments in the above-captioned Notice of Inquiry (NOI), in which the Commission is continuing its investigation of the potential for broader deployment of Dynamic Spectrum Access (DSA) technologies to promote wireless innovation and more efficient utilization of spectrum resources.[1] SSC strongly supports the Commission in its efforts to tackle the looming spectrum shortage by examining and promoting new and innovative wireless technologies such as DSA.

SSC is pleased that all commenters recognize the value of DSA and favor increased testing and further development of DSA technologies.[2] DSA benefits incumbent license holders,

[1] Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies, *Notice of Inquiry*, ET Docket No. 10-237, 25 FCC Rcd 13711 (Nov. 30, 2010) ("*DSA NOI*"). As the Commission noted in the DSA NOI, "its general flexible use policies and secondary market mechanisms already provide significant flexibility with regard to the use of dynamic spectrum management techniques" which " generally are designed to permit these types of arrangements so long as their implementation is consistent with the applicable service rules. *Id*. at ¶ 41; *see also id.* at ¶¶ 3-5 discussing other proceedings including the TV White Spaces, 3650-3700 MHz band, and DFS.

[2] *See, e.g.*, Land Mobile Communications Council (LMCC) Comments at 2-3; Microsoft Comments at 1-2; Public Interest Spectrum Coalition (PISC) Comments at 2-3; T-Mobile Comments at 3; Wireless Innovation Forum Comments at 1-2. *See also* Letter from Karl Nebbia, Associate Administrator, Office of Spectrum Management (OSM), National Telecommunications and Information Admin. (NTIA), to Julius Knapp, Chief, Office of Engineering and Technology (OET) (March 3, 2011) (OSM Letter) ("[NTIA] supports the goal of the [FCC NOI] to investigate dynamic spectrum access technologies and techniques that have the potential to enable more efficient utilization of our nation's spectrum resources.")

new entrants, and wireless consumers.[3] By providing more efficient access to spectrum, DSA allows more people to make more and better use of increasingly limited available spectrum. This will stimulate broadband growth and encourage innovation in wireless services and products. [4]

SSC's DSA technology produces these benefits through radio software applications and tools that allow for the automated reconfiguration of a radio device's transmission and reception parameters across multiple frequency bands.[5] SSC'S DSA technology, together with a policy-based regulatory framework, would resolve the concerns raised by many commenters, and thorough testing and demonstrations would settle any further doubts. The record in this proceeding supports the evolutionary, three-stage approach to DSA testing and deployment advocated in SSC's comments.

Several commenters gave examples of current, successful deployments of DSA and cognitive radio, as well as their vision for future deployment scenarios in licensed and unlicensed bands. Wireless network operators stated that they "already employ cognitive radio techniques in their own networks"[6] and observed that "commercial mobile wireless providers have long deployed dynamic spectrum sharing technologies in their networks to achieve more efficient and productive use of spectrum among the millions of subscribers they serve."[7] Technology companies such as QUALCOMM also commented on successful demonstrations of their DSA-

[3] *See, e.g.*, CTIA Comments at 2-3; Motorola Solutions Comments at 2; Wireless Internet Service Providers Association (WISPA) Comments at 1.

[4] *See, e.g.*, Google Comments at 1-2; PISC Comments at 2-3; WISPA Comments at 5.

[5] *See* Shared Spectrum Company ("SSC") Comments at 3-4.

[6] AT&T Comments at 8

[7] CTIA Comments at 7; see also Verizon Wireless Comments at 4.

enabled technologies.[8] Industry groups provided details on their completed and ongoing work to develop, inter alia: (1) requirements and standards for a variety of uses; (2) key enabling technologies, such as beaconing systems for detecting the presence of protected devices; (3) spectrum sensing techniques and interfaces; (4) policy language and ontology; (5) system architectures; and (6) security features.[9]

As SSC stated in its comments, the Commission can best promote wireless innovation and spectrum efficiency through DSA by adopting a policy-based regulatory framework that applies across multiple bands and wireless services.[10] In doing so, the Commission would be continuing its successful approach to more flexible rules across the regulatory landscape from licensed spectrum bands to unlicensed and licensed-light bands, and the eventual convergence of such bands. A policy-based framework for DSA that "cautiously" opens up many more spectrum bands for DSA-enabled sharing will not only "wring abundance from scarcity," as President Obama predicted, but will address all of the legitimate concerns raised in this proceeding.[11]

[8] *See, e.g.*, QUALCOMM Comments at 3-4 (describing femtocells, and their use in QUALCOMM's short-range wireless network technology); *see also*, Wireless Innovation Forum Comments at 4-6 (summarizing report on Quantitative Benefits of Cognitive Radio Technology).

[9] *See* IEEE 802.18 Comments at 2; IEEE DySPAN-SC Comments at 3, Wireless Innovation Forum Comments at 10-11.

[10] *See* SSC Comments at 14; *see also* IEEE DySPAN-SC Comments at 2 ("the benefits of the dynamic spectrum access techniques requires a regulatory framework that will encourage business development of products and services that utilized advanced DSA technologies.")

[11] *See, e.g.*, APCO Comments at 1 ("APCO urges the Commission to proceed very cautiously."); AT&T Comments at 21("AT&T cautions that any experimentation with policy devices must proceed very cautiously."); Motorola Solutions Comments at 15 ("a cautious approach must be adopted"); Southern Company Services ("Southern") Comments at 4 ("The FCC should proceed with caution . . . in bands that are used for utility and other CII applications.").

## II. THE RECORD IN THIS PROCEEDING SUPPORTS AN EVOLUTIONARY APPROACH TO DSA TESTING AND DEPLOYMENT

As SSC wrote in its initial comments, the Commission should facilitate an incremental, but expedited, approach to DSA deployment.[12] As many commenters noted, more testing must be done before true opportunistic spectrum access becomes a reality.[13] Therefore, SSC envisions a multi-stage approach, during which, as DSA technology improves and matures, the regulatory environment evolves to promote DSA deployment and robust spectrum markets. The first stage is the "internal" and "local" deployments of DSA-enabled technology and devices described by SSC and several other commenters. This would be followed soon by deployment "cooperatively" and then by "opportunistic" access capabilities, which are described in various ways in the record.

The first stage identified by SSC in its comments is already in progress as spectrum users across the industry begin to use DSA technologies within their own networks. SSC and others have worked with the Department of Defense (DoD) to put DSA software on military radios that operate on certain military bands.[14] As noted above, wireless network operators, technology developers, and standards organizations are employing cognitive radio techniques and developing standards. For example, according to Verizon Wireless and V-COMM:

> The advanced technologies wireless carriers are deploying today often use dynamic spectrum access technologies and ensure CMRS networks operate at the optimum level of spectrum efficiency and utilization. LTE, for example, uses sensing technology at the receiver used by the system in conjunction with advanced scheduler algorithms to optimize the use of CMRS spectrum. LTE also

[12] SSC Comments at 2.

[13] *See, e.g.*, Google Comments at 11; Motorola Solutions Comments at 23-24; T-Mobile Comments at 3-5.

[14] *See, e.g.*, Raytheon Comments at 1. *See also*, Antennas and Spectrum Analysis Division , U.S. Army Communications-Electronics Research Development and Engineering Center (CERDEC), *Notice of Ex Parte*, ET Docket 04-186 (Sept. 27, 2010) at 1-2; Lockheed Martin, *Reply Comments*, GN Docket 09-51 (Nov. 5, 2009) at 11.

> uses adaptive modulation that adjusts and optimizes spectrum usage according to the RF environment, dynamic power controls that adjust and optimize power levels a thousand times per second, advanced spectrum management techniques, MIMO antenna systems that use multiple polarities and diversity transmit and receive algorithms such as spatial-multiplexing, and other dynamic radio technologies to optimize spectrum utilization and efficiency. Finally, LTE devices use spectrum searching mechanisms to operate on appropriate bands in other markets when roaming and when switching to unlicensed wireless systems.[15]

As recognized in the National Broadband Plan and by several commenters, the Commission can further promote development of DSA in this stage by seeking additional funding for wireless test beds and further development.[16] Streamlining the experimental licensing process and finalization of the rules for TV band devices will also expedite innovation and deployment.[17]

The second stage identified by SSC in its comments – cooperative spectrum use – also finds broad support in the record, particularly in the context of for improving secondary markets and identifying certain government spectrum bands for repurposing. For example, as discussed further below, many commenters agree that secondary markets can be improved by increasing transparency of information regarding spectrum availability.[18]

Many commenters also agree that the third stage of DSA evolution envisioned by SSC – non-cooperative or opportunistic spectrum access – can only be achieved after appropriate real-

[15] Verizon Wireless Comments at 8 (footnotes omitted), citing V-COMM Comments at 18-19.

[16] *See* Federal Communications Commission, *Connecting America: The National Broadband Plan*, at Recommendation 7.6 (Mar. 16, 2010) ("*National Broadband Plan*") ("Wireless test beds can permit empirical assessment of radio systems and the complex interactions of spectrum users, which are nearly impossible to assess through simulation or analytical methods. As a result, they can reveal a great deal about how sharing can best be facilitated, how spectrum rights might be established, and the impact of dynamic spectrum access radios on existing and future communications services.") *See also* Motorola Solutions Comments at 24; Wireless Innovation Forum Comments at 17.

[17] *See, e.g.*, Google Comments at 4; PISC Comments at 19; WISPA Comments at 4; *see also* The Boeing Company, *Comments*, ET Docket 10-236 (Mar. 10, 2011) at 9; QUALCOMM, *Comments*, ET Docket 10-236 (Mar. 10, 2011) at 8-9.

[18] *E.g.*, Google Comments at 6; PISC Comments at 14-15; SSC Comments at 16-17.

world demonstrations of the efficacy of various interference-avoidance mechanisms. In the meantime, there are certain sensitive bands in which DSA-enabled devices should not be tested without the full cooperation and participation of incumbent users.[19] SSC agrees with several concerned commenters that the proper groundwork would need to be laid before enabling shared, dynamic access to certain bands on a non-cooperative basis.[20] This stage can be accelerated, however, by initially allowing policy-based opportunistic access in certain Federal government bands, subject to appropriate safeguards. Commission-imposed underlays or easements will be difficult to justify in heavily used or sensitive bands, especially while there are multiple underutilized bands available for shared access.

### A. The Importance of Test Beds and Demonstrations

Test beds and technology demonstrations are important in each stage of DSA's evolution. SSC agrees with the commenters in this and the companion experimental licensing proceeding that the Commission should open more spectrum for wireless test beds.[21] Many commenters suggested spectrum bands that are appropriate (or inappropriate) for testing and deployment.[22] For example, we support the Wireless Innovation Forum's renewed proposal to include in a test

[19] *See, e.g.*, APCO Comments at 2; National Public Safety Telecommunications Council ("NPSTC") Comments at 6; Satellite Industry Association ("SIA") Comments at 5; Southern Comments at 6.

[20] *See, e.g.*, PISC Comments at 2 ("Advancing the public interest in promoting pervasive connectivity, innovation, and consumer welfare suggests that the Commission also should lay the groundwork for complementary spectrum access models that focus on enabling shared, dynamic access to unused and underutilized bands."); T-Mobile Comments at 3-4; Verizon Wireless Comments at 19.

[21] *E.g.*, Verizon Wireless, *Comments*, ET Docket 10-236 (Mar. 11, 2010) at 5.

[22] *E.g.*, Motorola Solutions Comments at 8-9; PISC Comments at 34-35; T-Mobile Comments at 6-9; Wireless Innovation Forum Comments at 17.

bed program operations above 1 GHz, in order to allow experiments that account for the unique propagation characteristics and different interference-avoidance mechanisms in various bands.[23]

SSC also requests that the Commission support additional funding for spectrum sharing test beds. A lack of funding is a primary barrier to testing DSA technology, particularly when the regulatory framework is so uncertain, as it invariably is, during the early stages. Commenters suggest that the promise of test beds to significantly advance DSA technology, widespread deployment of cognitive radios, and spectral efficiency, can only be achieved with adequate funding.[24]

## B. The Role of Robust Secondary Markets for Enabling DSA

Secondary market mechanisms are particularly important to supporting cooperative shared access to spectrum in the second stage of DSA evolution. As many commenters note, secondary market mechanisms can be extremely important to meeting the increasing demand for spectrum.[25] In its initial comments, SSC made a number of suggestions for how secondary markets can be improved to facilitate cooperative spectrum use.[26] These improvements, suggested by SSC and others, include: (1) increasing transparency of information regarding spectrum availability;[27] (2) providing incentives to lease spectrum by clarifying build-out and

[23] Wireless Innovation Forum Comments at 17 ("Moreover, a new spectrum sharing test-bed for bands above 1 GHz (*e.g.*, 1755-1850 MHz and 3550-3650 MHz) could provide a proving ground for efficient broadband technologies and spectrum sharing techniques for spectrum with line of sight propagation characteristics.").

[24] Motorola Solutions Comments at 24 (proposing National Science Foundation or DARPA-like agency funding), Wireless Innovation Forum Comments at 17.

[25] *E.g.* Ericsson Comments at 20-21

[26] SSC Comments at 17

[27] *E.g.* PISC Comments at 14-15, SSC Comments at 16-17.

eligibility rules; (3) harmonizing flexible allocations and technical rules across multiple bands; and (4) expand secondary market policies to all spectrum-based services.[28]

Some commenters also suggested changes to the auction mechanism itself, including a move to dynamic auctions[29] that would require "payment for spectrum use on an as-needed basis, rather than months or years in advance."[30] SSC supports more dynamic auctions, particularly ones involving the use of cognitive radio technologies to support automated real-time, auctions as described in detail by the Wireless Innovation Forum.[31]

## C. Frequency Bands Suitable for DSA

A wide variety of ideas was expressed in the comments about suitable or unsuitable bands for deploying DSA technology. While several commenters suggested that DSA is not ready for use in certain licensed bands, such as those primarily used by satellite,[32] radio astronomy,[33] commercial mobile,[34] and public safety/critical infrastructure[35] services, most commenters support the use of DSA technologies in unlicensed[36] or Federal[37] spectrum. Those

[28] SSC Comments at 17

[29] Wireless Innovation Forum Comments at 7-8

[30] Google Comments at 8

[31] Wireless Innovation Forum Comments at 7-8

[32] *See* SIA Comments at 2-3.

[33] *See* National Radio Astronomy Observatory Comments at 2-3; s*ee also* National Research Council, "Spectrum Management for Science in the 21st Century" at 187 and 190 (National Academies Press, Washington, D.C.) (2010), *available at* http://www.nap.edu/catalog/12800.html.

[34] *See, e.g.*, CTIA Comments at 11; Verizon Wireless Comments at 9-10; AT&T Comments at 3-5.

[35] *See* APCO Comments at 1-2; NPSTC Comments at 4,7; Southern Comments at 3-4.

[36] *See, e.g.*, AT&T Comments at 5; PISC Comments at 33; Ericsson Comments at 14-16.

[37] *See, e.g.*, AT&T Comments at 5; PISC Comments at 28-32; T-Mobile Comments at 7-8.

parties that opposed DSA in "their" bands assumed that such use would be on a non-cooperative basis under "forced" sharing arrangements.[38]

As mentioned above, SSC agrees that it would be premature to consider involuntary or uncoordinated sharing in these or other already crowded or sensitive bands, but the Commission should provide increased flexibility for these services to implement or permit DSA and cognitive radio technologies to be deployed on a cooperative or internal basis. In addition to unlicensed bands, including the new bands recently authorized for TV band devices, SSC also agrees that those Federal government bands that are intermittently used or geographically focused are strong candidates for sharing through DSA technologies.

*Flexible Use Bands*. As recognized in the *NOI* and by several commenters, in certain "flexible use" bands, such as those currently used for commercial mobile services, the Commission already gives licensees (and lessees) "wide latitude to adopt and implement spectrum management techniques to manage access to and use of their spectrum, *so long as that use is consistent with the applicable rules relating to the spectrum band and the prevention of harmful interference*."[39]

The Commission seeks "to enable or promote the use of dynamic radios in spectrum licensed for flexible use" on a cooperative or internal basis, while still ensuring the "prevention

[38] *See, e.g.*, AT&T Comments at 6 (DSA technologies should not be uses in licensed mobile spectrum "except under the sole control of the licensee").

[39] DSA NOI at ¶ 36 (emphasis added). See also id at ¶40 ("The technical parameters for these [private commons] devices, in turn, enable users to operate in a manner designed to minimize interference concerns relating to other users in the licensed band *so long as the devices comply with the applicable technical requirements and use restrictions under the license authorization itself*.") and ¶ 41 ("While the Commission to date has declined to address any specific dynamic spectrum management technique or business model that has been suggested, it has underscored that the flexible use policies generally are designed to permit these types of arrangements *so long as their implementation is consistent with the applicable service rules*.") (footnotes omitted, emphasis added).

of harmful interference."[40] To achieve this goal, it is imperative that the Commission allow exceptions to some of the "so long as" conditions, "technical requirements," and "use restrictions" currently embedded in the rules for DSA-enabled devices that meet specific minimum hardware and software capabilities.[41] This combination of added flexibility and appropriate safeguards could, for example, allow policy-based, DSA-enabled radio systems to be deployed in rural areas under more relaxed restrictions than those imposed on "flexible use" systems in urban areas,[42] or allow temporary use of, or out-of-band emissions into, auction "leftovers" or fallow frequencies.

*Inflexible Use Bands.* For the large amount of spectrum still governed by "command-and-control" type regulations, increased flexibility through the targeted removal of potential regulatory barriers in these services will allow incumbents to pool spectrum resources on an as-needed, temporary basis to meet demand spikes during emergencies,[43] or provide ancillary or supplemental services utilizing DSA and cognitive radio technology. Again, these uses could occur only on a cooperatively coordinated or internal basis. Such barriers may include, for example, eligibility restrictions that prevent, as one commenter suggested, public/private cognitive radio systems that could successfully co-exist in well-controlled environments.[44] Other

[40] DSA NOI at ¶¶ 36-37.

[41] *See* SSC Comments at 21. These capabilities would enable standardized policy controls and policies managed, for example, by third-party band managers and any exceptions would require a built-in enforcement apparatus to implement interference deconfliction measures and remedies. *See also* Wireless Innovation Forum Comments at 10-16, IEEE 802.18 Comments at 5 and IEEE DySPAN-SC Comments at 11-13.

[42] *See* xG Technologies Comments at 8; s*ee also Facilitating the Provision of Spectrum-Based Services to Rural Areas and Promoting Opportunities for Rural Telephone Companies to Provide Spectrum-Based Services*, WT Docket Nos. 02-381 et al., Report and Order and Further Notice of Proposed Rule Making, 19 FCC Rcd 19078 (2004).

[43] *See, e.g.*, Wireless Innovation Forum Comments at 8-10 and Appendix B; QUALCOMM Comments at 7.

[44] *See* Motorola Solutions Comments at 10. ("For example, public safety users and private utility users may be able to eventually share an LTE-based broadband system by utilizing dynamic spectrum sharing techniques (*e.g.*, through

potential measures that would improve spectrum efficiency through cooperative or coordinated DSA deployment among licensees and other eligible users in restricted use bands include the following:

- Clarification that "decentralized trunking" monitoring capabilities through DSA-enabled devices could be introduced onto shared channels in the private land mobile radio (PLMR) bands below 512 MHz pursuant, consistent with the Commission's existing Part 90 rules, and provide regulatory relief in connection with the 10-channel limitation and leasing restrictions on a temporary basis when needed;[45]
- Provide digital full power, Class A, and LPTV licensees the flexibility to offer "ancillary or supplementary services" using TVBDs, by allowing them to negotiate or internally implement more flexible TVBD co-channel and adjacent channel operational requirements that both enable such services and ensure against disruption of TV service and electronic news gathering.[46]
- Allow coordinated or leased access to fixed satellite bands for terrestrial, DSA-enabled uses on a temporary, as needed basis.[47]

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the use of near real-time spectrum databases, and sensing techniques with priority service pre-emption), thereby increasing spectrum utilization and efficiency.")

[45] See D.N. Hatfield, P.A. Tenhula, "The Potential Value of Decentralized Trunking as Regulatory Precedent for the Introduction of Dynamic Spectrum Access Technology," DYSPAN 2007 - IEEE Symposium on New Frontiers in Dynamic Spectrum Access Networks, pp. 597-605, April 2007, *available at* http://www.sharedspectrum.com/wp-content/uploads/SSC-DySPAN-2007-Hatfield.pdf. *See also* Southern Comments at 8 and n.10, citing 47 C.F.R. 90.187.

[46] *See* Shared Spectrum, *Ex Parte Letter*, ET Docket No. 04-186 (Aug. 11, 2010).

[47] See, e.g., Motorola Solutions Comments at 12, citing P. Anker, *Cognitive Radio, the Market and the Regulator*, Proceedings DySPAN 2010, *available at* http://www.telecomabc.com/specials/dsa/resources/dyspan2010-cr-market-regulator.pdf.

*Federal Government Bands.* SSC's initial comments suggested that the 1675-1710 MHz, 1755-1780 MHz, and 3500-3650 MHz bands are very suitable candidates in which to deploy DSA technologies. Several other commenters also identified these and other Federal government bands for sharing with DSA and cognitive radio technologies.[48] While NTIA has not had an opportunity to analyze "new sharing methods" such as DSA, SSC encourages "the Commission to work with NTIA and other Federal and non-Federal stakeholders on a transparent basis to carefully evaluate new and existing spectrum sharing approaches, including geographic coordination, dynamic frequency selection ('DFS') and DSA." [49]

SSC is pleased to see that the Commission staff recently requested specific comments on alternatives to exclusion zones in these bands, which could enable broadband wireless systems to operate "more efficiently on a co-channel, co-coverage basis with the [Federal satellite] Earth stations using time sharing techniques."[50] With regard to the exclusion zones that NTIA has recommended for the 3.5 GHz band along the coasts, the Spectrum Task Force noted that "there will be periods when the radars are not operating" and invited comment "as to whether there are techniques that can be developed to enable co-existence with the ship-borne radars, such as dynamic spectrum access, to avoid use of this spectrum when interference is present and instead move communications traffic to other spectrum."[51]

NTIA's Office of Spectrum Management (OSM) has also raised important questions and technical issues to assess the electromagnetic compatibility between DSA-enabled devices and

[48] See Grunwald Comments at 7; AT&T Comments at 5; PISC Comments at 28-32; T-Mobile Comments at 7-8.

[49] SSC Comments at 22.

[50] Public Notice, "Spectrum Task Force Requests Information on Frequency Bands Identified by NTIA as Potential Broadband Spectrum," *Public Notice*, ET Docket No. 10-123, DA No. 11-444 (Mar. 8, 2010).

[51] *Id.*

incumbent spectrum users.[52] These issues primarily relate to potential "interference scenarios," as well as deterministic and probabilistic "analysis methodologies."

SSC looks forward to assisting the Commission to further develop a record in support of DSA-based spectrum sharing in these and other Federal bands. In addition to addressing the questions raised by the Commission and NTIA staff, SSC plans to identify additional information that could be provided by the Commission, NTIA, and other Federal agencies that is critical to properly developing appropriate policies and requirements to enable a dynamic sharing regime in these bands. As some commenters mentioned, a major obstacle, particularly in the Federal bands, is the lack transparency with respect to the types of systems, technical parameters, and actual uses. These data need to be part of a meaningful spectrum inventory that can facilitate shared access for new broadband uses.[53]

### D. The Need for a Comprehensive and Ongoing Spectrum Inventory to Identify Additional Spectrum for DSA[54]

SSC agrees with the commenters in this and other proceedings that urge the Commission and NTIA to conduct a comprehensive spectrum inventory. While such an inventory has many purposes and will serve a wide variety of interests, it should at least measure – and disclose – the effective utilization of key Federal and non-Federal spectrum bands so that stakeholders can provide informed input regarding bands suitable for reallocation and dynamic spectrum access.[55] SSC has strongly supported regulatory and legislative efforts to gain better knowledge of

[52] *See* OSM Letter, supra. n. 2.

[53] *See* Google Comments at 6-7; PISC Comments at 31.

[54] *See generally* George I. Seffers, "Dynamic Spectrum Access Bursts Into Airwaves," SIGNAL Magazine (Nov. 2010), *available at* http://www.afcea.org/signal/articles/templates/Signal_Article_Template.asp?articleid=2433&zoneid=303.

[55] *See* Google Comments at 5-6.

whether, and if so, how, valuable spectrum resources are being used.[56] Pursuant to the National Broadband Plan, the Commission has taken some steps by launching the "Spectrum Dashboard" and "License View" databases that, according to Chairman Genachowski, only represents a "baseline" inventory of who holds licenses in non-Federal spectrum bands.[57]

SSC is pleased to see that the Commission is still exploring ways to "more exhaustively inventory spectrum, including measuring actual use" because additional information *will* be necessary to "stimulat[e] secondary markets and dynamic spectrum use."[58] However, SSC disagrees that such an endeavor, including spectrum occupancy measurements, will cost "tens of millions of dollars" and take "several years" to complete.[59]

First, to incorporate unclassified Federal spectrum information into its databases, the Commission can leverage investments made by DoD and NTIA in their development and implementation of a "Standard Spectrum Resource Format" (SSRF) and data dictionary for exchanging and processing all data related to spectrum management.[60] Second, with regard to

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[56] *See* Shared Spectrum Company, *Reply Comments*, GN Docket No. 09-51 (July 21, 2009); Testimony of Thomas Stroup, CEO, Shared Spectrum Company, before the U.S. House of Representatives Committee on Energy and Commerce, Subcommittee on Communications, Technology and the Internet, on H.R. 3125, The Radio Spectrum Inventory Act (December 15, 2009).

[57] *See* Letter from Julius Genachowski, FCC Chairman, to Senator Olympia J. Snowe (March 8, 2011), *available at* http://www.fcc.gov/Daily_Releases/Daily_Business/2011/db0316/DOC-305230A1.pdf.

[58] *Id.*

[59] The Congressional Budget Office (CBO) estimated that implementing H.R. 3125, which passed the House of Representatives last year, would "increase net discretionary spending by $16 million" over the next five years. CBO Estimate for H.R. 3125, Radio Spectrum Inventory Act (March 22, 2010), *available at* http://www.cbo.gov/ftpdocs/114xx/doc11412/hr3125.pdf. Similarly, the National Broadband Plan estimated that a spectrum utilization study like one conducted in the United Kingdom, "scaled to the larger scope of U.S. geography, would cost approximately $10–$15 million, and would provide insight into the utilization of spectrum resources with trillions of dollars of social value. Spectrum measurement for this study could use inexpensive frequency scanners installed on postal trucks or other fleet vehicles." *National Broadband Plan* at Recommendation 5.2 (March 2010), *available at* http://www.broadband.gov/plan/5-spectrum/#r5-2.

[60] *See* Military Communications Electronics Board (MCEB) Publication 8, "Standard Spectrum Resource Format" (March 2009), *available at* https://acc.dau.mil/CommunityBrowser.aspx?id=283273.

gathering information on spectrum occupancy and utilization, SSC previously recommended a limited series of studies to supplement the consolidated FCC-NTIA database.[61] Specifically, based on its extensive experience in collecting spectrum data, SSC suggested "an initial series of spectrum occupancy studies at a diverse set of 10 to 20 fixed locations, and augmented by mobile data collections, in urban and rural areas over several days or weeks."

These studies would assess the full range of spectral, temporal, spatial, orientation, power spectral density, and related issues and variables. Bands with low occupancy and large spectrum holes (time and frequency) can be checked against the consolidated assignment database (including the predicted transmission patterns for fixed transmitters) to determine if the measurements should have been able to detect signals if they were present. Long-term spectrum observatories could be set up by the Commission, NTIA, universities and other parties at a variety of locations around the country to provide a steady source of usage data that will validate early results, observe trends in spectral usage over long periods (years), identify usage patterns and anomalies, and confirm the positions of spectral holes in time and space. Finally, if necessary, licensee surveys or audits, as well as a publicly accessible "wiki," can be used to confirm existing information or gather additional usage data.[62]

Over the last few years, DSA has "transitioned from a laboratory curiosity to a practical, beneficial, deployable technology as part of a larger trend to incorporating artificial intelligence into information processing systems and will continue to evolve in surprising ways."[63] The record in this proceeding supports the continued evolution of DSA technology and regulation

[61] *See* Shared Spectrum Company, *Reply Comments*, GN Docket No. 09-51 at 4-6 (July 21, 2009).

[62] *Id.*

[63] Wireless Innovation Forum Comments Appendix A at 123.

through the three stages described above. Below, SSC describes how its DSA technology is responsive to the concerns of commenters, even in this first stage, and how the technology will improve through the following two stages.

## III. DSA TECHNOLOGY AND A POLICY-BASED REGULATORY FRAMEWORK WOULD RESOLVE THE CONCERNS RAISED BY COMMENTERS

A few commenters outline several factors or concerns that DSA technology would need to address.[64] For example, some commenters address how the complexity of interference avoidance increases exponentially in the move from internal use by a single service provider to a large scale opportunistic mobile network,[65] when deployed in bands with differing power levels and antenna heights,[66] or when a variety of equipment is in use.[67] These varying scenarios reflect one of the primary reasons that SSC envisions a three-stage approach to DSA evolution. It is not until late in the third stage that SSC envisions opportunistic use, after DSA is proved sufficiently successful at avoiding interference in unlicensed bands, in cooperative sharing arrangements, and in internal use scenarios. We address below (and in our initial comments) the bulk of the concerns related to preventing harmful interference and security issues. A policy-based regulatory framework would resolve many of these.

[64] *See, e.g.*, Ericsson Comments at 18-19; LMCC Comments at 6; T-Mobile Comments at 6-9; APCO Comments at 2; Motorola Solutions Comments at 13-19; Wireless Innovation Forum Comments at 6.

[65] Ericsson Comments at 7.

[66] NPSTC Comments at 3.

[67] APCO Comments at 2 (also discussing concerns with interference because of "narrow channel bandwidths, interleaved channel assignments across service pools, the huge number of diverse and distinct licensees, the wide variety of deployed equipment, the intermittent use of channels in many instances, trunking systems, and the sensitive nature of the communications being transmitted by public safety and critical infrastructure licensees.")

## A. Harmful Interference

Many commenters expressed concerns with potential harmful interference from DSA-enabled spectrum sharing. SSC's DSA technology is designed specifically to avoid harmful interference to incumbent systems, but we also agree that DSA-enabled devices need to be adequately controlled and tested.

Yet even at this early stage, SSC's DSA technology is responsive to the specific interference concerns raised by commenters. It provides a way, once devices are deployed, "to control and modify the devices to address potential problems or changed conditions."[68] SSC's policy radio technology allows for updating radios after they are in the hands of consumers. Further, SSC's approach would enable regulators, manufacturers, service providers, or primary users to require that radios stop operating if their operational protocols are not updated within a specified time frame. This dynamic, real-time, updating of radios can occur through any combination of spectrum sensing, database lookups, beacons, and manual update requirements incorporated into or pushed to the device.

Policy-based, DSA-enabled devices operating across different bands can make use of different interference avoidance mechanisms, which are discussed below.[69] Adequately funded test beds will provide additional opportunities for examining interference avoidance techniques, including the several successful techniques cited in the appendix to the Wireless Innovation

[68] T-Mobile Comments at 9.

[69] *See* Wireless Innovation Forum Comments at 17; IEEE DySPAN-SC Comments at 3; National Radio Astronomy Observatory Comments at 2.

Forum's comments.[70] With regard to concerns about spectrum sensing in particular, these are addressed below in Section IV.

## B. Security

A few commenters cite particular security concerns that SSC already addresses in its DSA technology.[71] One difference between DSA-enabled, policy-controlled software defined radios and other wireless devices is that the former will likely be even more secure and resilient than most existing devices. For example, SSC's DSA systems "allow for strong user authentication, policy encryption, secure local and remote policy repositories, configuration management, and logging device activity."[72]

SSC also uses a policy certificate security management feature that is managed only by authorized stakeholders through a set of the policy authoring, validation and administration tools. The tools are only accessible with a secure user name and password that must correspond to the encrypted certificate used to sign each message and policy transmitted to or from DSA-enabled devices.[73] Therefore, only authorized users can access and adjust the radio's policy controls.

Commenters also express concerns with enforcement.[74] SSC strongly supports the notion that enforcement must go hand-in-hand not only with the deployment of DSA-enabled devices but with the general trends leading to the wide-scale proliferation of radiofrequency devices. Policy-based radios give incumbent licensees and the Commission a variety of options to

[70] Wireless Innovation Forum Comments Appendix A at 17-18.

[71] *See, e.g.*, AT&T Comments at 20-21; Wireless Innovation Forum Comments at 14-16.

[72] R. Foster, P. Tenhula, M. McHenry, and F. Perich, "Cognitive Radio Access for Public Safety," SDR '09 Technical Conference (Dec. 2009), *available at* http://groups.winnforum.org/d/do/2445.

[73] *Id.*, at 4

[74] *See, e.g.*, CTIA Comments at 14-17.

enhance enforcement efforts. For example, primary spectrum users can include leasing terms that allow them to quickly and remotely shut down secondary DSA-enabled devices that are potentially causing problems. The Commission, as well as the primary user or some other policy manager, can quickly force interfering devices off the spectrum or into another band. While traditional complaint-based enforcement mechanisms are always available, with various administrative penalties provided by Title IV of the Communications Act, further review of the Commission's interference dispute resolution processes is necessary.[75]

## IV. POLICY-BASED, DSA TECHNOLOGY USES A COMBINATION OF TOOLS, INCLUDING SPECTRUM SENSING, DATABASES, SECURE POLICY RULES AND CONTROLS AND OTHER APPROACHES FOR ASSESSING AND ADJUSTING TO THE SPECTRUM ENVIRONMENT

Though an important part of a DSA system, spectrum sensing is one of a number of methods through which policy-based radios and other DSA-enabled devices can respond to other spectrum activity. Other methods include real-time databases, beacons, time-limited leases, geolocation restrictions and policy-based controls. SSC agrees with those commenters that suggest that a combination of these is the best way forward, depending on a range of factors and circumstances across bands and deployment scenarios.[76]

[75] *See generally*, Reply Comments of The Samuelson-Glushko Technology Law and Policy Clinic at the University of Colorado.

[76] IEEE DySPAN-SC Comments at 7.

## A. Sensing

Many commenters suggested that spectrum sensing technology is not ready for widespread deployment.[77] Some cite the Commission's TV White Spaces proceeding as highlighting the limits of spectrum sensing technology.[78] As a pioneer in addressing many of the concerns with spectrum sensing raised by commenters, SSC's DSA systems already include several types of detectors for spectrum sensing as part of a cost-effective, software-based approach, including capabilities to address the so-called "hidden node" problem. Moreover, SSC is currently working on innovative approaches to address the noise-floor and man-made noise issues. To resolve commenters concerns with spectrum sensing, SSC recommends additional testing and demonstrations of multiple approaches, including collaborative sensing and a range of signal detection techniques.

SSC has either resolved or is working to resolve the other concerns raised by commenters regarding sensing. For example, one concern raised was that low-power mobile two-way radios would be more difficult for DSA technology to address than high-power fixed transmitters (*i.e.*, TV stations).[79] This concern reflects three legacy system factors (mobile/fixed, low power/high power, and one-way/two-way) that need to be examined in combination to determine how a DSA-based system would approached these various scenarios. Each of these factors impacts the technical sensing approach differently. In general, a legacy system with a two-way architecture is better suited for sensing approaches since all legacy radios are directly "visible" to DSA detectors. Where there are receive-only legacy nodes in a one-way architecture, spectrum

[77] *See, e.g.*, CTIA Comments at 16; Motorola Solutions Comments at 4; T-Mobile Comments at 4.

[78] *E.g.* T-Mobile Comments at 4.

[79] *See* Motorola Solutions Comments at 4.

sensing is more challenging and may be augmented with geolocation or other interference avoidance methods. With regard to power levels, it is obviously easier to detect higher power legacy systems than low-power systems. The power, in addition to other parameters such as signal bandwidth, helps determine the required DSA detector sensitivity and type. Mobility is actually not a major factor that needs to be addressed because, at least in the case of SSC's DSA system, it is capable of rapidly sensing the spectrum compared to the received signal change rate (due to mobility), and responding thereto. Also, a mobile DSA system has relative motion with respect to a fixed or a mobile legacy system; hence, the DSA system treats fixed or mobile legacy systems in a similar fashion.

Commenters also raised concerns with hidden nodes, for example, low antenna heights, low antenna gains, body losses, polarization mismatches, and other real-world effects.[80] SSC's two-way DSA radios account for all of these propagation loss factors, as each path is measured independently. Another concern raised in the comments related to the speed and "bursty nature of typical two-way radios."[81] However, the "bursty" transmission of a voice signal is easily detected by a DSA transceiver because the DSA detector samples at a high rate. SSC's DSA system samples the spectrum once every 10 to 20 milliseconds, so within a 1 second long voice burst, there are at least 50 opportunities to sense the signal.

In response to concerns that man-made environmental noise increases the noise-floor, this impacts the DSA detection false alarm rate, and not the incumbent signal detection probability. So long as there are other channels available, the DSA transceiver will continue to operate. If there are no additional channels available, then the DSA transceiver will not transmit. Man-

[80] *See Id.*

[81] *See Id.*, at 6

made noise impacts all radios (DSA and non-DSA). The introduction of man-made noise into an operational environment, in which properly designed DSA radios have been deployed, does not create an additional interference risk to the incumbent users.

## B. Databases

A number of commenters suggest that the Commission use the TV white spaces database as a model for applying DSA capabilities to additional spectrum bands.[82] However, commenters noted that the usefulness of any such database depends on it having mechanisms for real-time updating as well as rules requiring additional transparency of spectrum users.[83] Other concerns with the use of databases that need to be resolved include the cost of implementing geolocation requirements and the fees charged by database managers, as well as the issues that arise with geolocation when the radios are located indoors, are at elevated heights, or are highly mobile.

This is why SSC supports the use of policy databases in conjunction with sensing and other DSA approaches. At the same time, spectrum sensing can "provide a valuable, independent check on the accuracy of localized information regarding protected operations contained in or missing from the geolocation database."[84] The effectiveness of DSA increases as it receives more and more accurate inputs regarding other uses of the various channels on which the radio can operate.

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[82] *E.g.*, Google Comments at 4; Microsoft Comments at 1; PISC Comments at 17.

[83] *E.g.*, LMCC Comments at 6-7 (suggesting the utility of the spectrum dashboard could be "enhanced if it also included the following elements on a band/service-specific basis: (i) explanation of user eligibility; (ii) availability of FCC-approved equipment; (iii) methods by which potential users may acquire spectrum, *i.e.*, licensed, unlicensed, auction, secondary market transactions or site-specific licensing requirements.)

[84] Shared Spectrum Company, *Notice of Ex Parte Communication*, ET Docket No. 04-186 and GN Docket Nos. 09-51 and 09-157 (Aug. 12, 2010).

## C. Policy Controls

Commenters suggested that policy-based radios could also play an important role in managing DSA and cognitive radio technology.[85] Using a policy language-based approach, DSA radios can capture and respond to geolocation, time-of-day, power level, and any other requirements and restrictions on radio transmission. SSC's policy-based radios are flexible and updateable in real-time; they can resolve the overlapping, and perhaps conflicting, rules imposed by a variety of stakeholders, allowing for quick deployment even in novel environments.

The most effective DSA radios will use a combination of these technologies. Cooperating entities will be able to assess which combinations of policies work best in their specific situation, and which data are most necessary to support a specified level of service and a lack of interference. The lessons learned by these cooperating entities will provide the groundwork needed to develop a policy-based approached for opportunistic devices.

SSC supports the efforts of the Wireless Innovation Forum and IEEE DySPAN-SC in developing use cases, languages, architectures and standards for policy-based DSA systems. We also encourage the Commission to actively monitor and participate in these efforts.

[85] *See, e.g.*, IEEE 802.18 at 2 (mentioning publication of standard for using beaconing technology).

## V. CONCLUSION

SSC reiterates its support for the Commission's inquiry and commitment to finding new and innovative approaches to increasing spectrum efficiency. Though we recognize the many concerns of commenters regarding interference, security, and spectrum sensing, it is only by moving forward with development and testing of DSA radios that these concerns can be addressed. Therefore, we urge the Commission to begin by developing a policy-based framework for DSA across multiple bands and propose sharing rules for federal spectrum bands that take into account incumbent requirements and incentives.

Respectfully submitted,

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